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Reconstruction of the History of a Thermokarst Lake in the Mid-Holocene Based on an Analysis of Subfossil Cladocera (Siberia, Central Yakutia)

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Abstract—This paper presents the results of a cladoceran analysis of a sediment core with a lenght of 382 cm collected from a pingo in alas Khara Bulgunnyakh located in Central Yakutia. Based on the Cladocera analysis results, the formation of the lake had started during the Holocene climatic optimum ~6600 cal. yrs. BP. The analysis of changes in the species composition of subfossil cladoceran communities made it possible to identify, on the basis of cluster analysis, four statistically significant ecological zones. The period of optimal conditions for the Cladocera community is defined by a complex evened community structure and numerous cladoceran remains in the sediments accumulated between 6500 and 6000 cal. yrs. BP. The history of the thermokarst water body development and existence reconstructed on the basis of the subfossil cladoceran analysis was rapid and short.

Keywords: Holocene, subfossil Cladocera, thermokarst lake, Lena–Aldan interfluve, Central Yakutia
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INTRODUCTION

Central Yakutia encompasses vast areas in the middle reaches of the Lena River, middle and lower reaches of the Aldan and Vilyuy Rivers, and Lena–Vilyuy and Lena–Amga interfluves; it is located entirely in the cryolithozone. The thermokarst phenomenon (transformation of the land surface due to the thawing of icy permafrost and melting of ground ice, resulting in the development of funnel relief or microrelief forms with subsequent formation of thermokarst lakes) is broadly presented in the study area (Kachurin, 1961; Bysyina, 2009; Bosikov et al., 2012).

The degradation of thermokarst lakes creates unique natural landscapes of Central Yakutia, so-called 'alases'—hollows formed by the melting of deposits of the 'Ice Complex' with syngenetic repeated–vein ice (Ershov, 2002). During their further development, these pass through a number of stages and transform into hollows, either dry or having a small residual lake, with a unique complex of such facies as bulgunnyakhs (frost mounds) and pingos, forbs–gramineous meadows on swamp soils, etc. (*Stroenie*..., 1979; Ivanov, 1984; Bosikov, 1991).

The development of thermokarst processes is largely determined by the climate or factors associated with it, including the atmospheric temperature, amount of precipitation, evaporation, and moisture content (Kirpotin et al., 2008; Rodionova, 2013), but many processes underlying the effect of climate changes on multiyear cryogenic deposits are currently researched insufficiently (Konishchev, 2009).

Modern studies of the dynamics of thermokarst lakes and alas ecosystems are considerably supplemented with paleoecological studies of the Holocene and late Pleistocene sediments that make possible to reconstruct the history of thermokarst lake formation and the existence in the past in order to understand the current patterns of thermokarst processes, forecast their future development, and assess the environmental condition of study regions (Akramov, 1967).

The following biological paleoindicators, whose siliceous and chitinous carapaces are normally well-preserved in bottom sediments, are used in the studies of water bodies: diatoms (Palagushkina et al., 2012), pollen (Rudaya et al., 2012), chironomid remains (Nazarova et al., 2015), and ostracods (Kienast et al., 2011). The 'youngest' paleobiological analysis type is cladoceran analysis based on the identification of chitinous structures of Cladocera external skeletons (head-